Difference in Evaluating the Effectiveness of a Certain Cockroach Repellent by Various Testing Methods Insect Repellents and Attractants VIII

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6. Total number of pupae produced by a female was gradually decreased from 119.9 to 0.3 in each five days interval during 25 days of her reproductive period (Fig. 2).

7. The mating of male was observed even at 32 days after his emergence. It seems that the decline of reproduction depends chiefly on factors in female itself than those of male, so far as the observation period of 25 days is concerned.

Difference in Evaluating the Effectiveness of a Certain Cockroach Repellent by Various Testing Methods. Insect Repellents and Attractants. VIII. Yasunosuke IKEDA (Takamine Laboratory, Sankyo Co., Ltd. Yasu-cho, Shiga Pref.). Received Apr. 30, 1959. *Botyu-Kagaku,* **24**, 83, 1959.

17. 試験方法が忌避剤の効力値の変動に及ぼす影響　忌避剤・誘引剤について　第8報

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ゴキブリ忌避剤の実用効果を測定する方法はほとんど見当らない．この実験において，ゴキブリ忌避剤の効力試験方法が，その効力評価値の変動に大きく影響することを知った．

There have been several methods determining the effectiveness of cockroach repellents. In the present work, it was reported testing methods that indicate high efficiency of evaluation of the effectiveness of a certain cockroach repellent.

In the present paper, the author compares some methods for evaluation of the effectiveness of a certain cockroach repellent in laboratory, and discusses the correlation between the testing method and the result obtained.

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Material

The material used was adults of the American cockroach, *Periplaneta americana* Linné, reared on the Oriental's Rat Food NMC5 (Pellet for the rearing of experimental animals, made by Oriental Yeast Manufacturing Co.). It had been bred for 3 years in this laboratory. In the test, adult roaches were selected at random without regard to sex, and 40 roaches were used for each test.

The sample tested in the present experiment was MGK repellent 11 (2,3,4,5-bis (Δ^2 butylene) tetrahydrofulfural), one of the cockroach repellent widely used[1,2]. Samples were dissolved in acetone at a rate of 10 mg and 20 mg in each of 1 cc of test solution.

a) Evaluation of the Effectiveness of Cockroach Repellent by Shelter Method[3,4]

The method employed in the first test is the one, which were recommended for the evaluation of cockroach repellents[3,4]. The criterion of repellency is based on the habit of roaches hiding in sheltered places away from light. The roach shelters consist of cartons with entry holes near the base. In the tests, two shelters, one of which is treated with test material while another is untreated, are placed in the test cage containing given number of roaches. The light forces the roaches to seek shelter and to select the one of shelters which is comfortable to them. If concentration of the repellent is enough, the roaches will be found in the untreated shelter.

The test cages consisted of corrugated cardboard, 40×30×20 cm, with glass window on either side wall to allow light streams. The roach shelters used were 10×10×8 cm. They consisted of cartons with holes cut in large enough to allow roaches to enter. In the case of test, the entire inner surface of the cartons was treated with acetone solution of a given amount of the test repellent. A pair of two

shelters, the treated and untreated, was placed in the corners of the cage so that their entry holes faced each other. Food and water were provided at the center of the cage. Then, the roaches were introduced into the cage. The tests were made in the room lighted with fluorescent lamps which were on 10 hours and off 14 hours. Roaches inhabiting shelters were counted once each day during the test period. The results are given in Table 1.

b) Behavior of Cockroaches in the Shelter Method

As shown in Table 1, MGK repellent 11 gave high effect in repelling roaches. However, the good results of these tests reflect the reorientation of the roaches. In order to make sure the habit of roaches to hide in the shelter of their choice under the controlled condition, the following tests were performed.

The methods and conditions were nearly the same to those mentioned above. In the second test, however, after the roaches had settled in a shelter of their choice, an untreated shelter was placed. Then, the roaches that move into the new shelter were observed. As shown in Table 2, at first the roaches preferred the shelter where they had long lived, and they did not live in the new shelter notwithstanding it was untreated, and gradually

Table 1. Percentage of roaches inhabiting shelters. Average of two replicates (at 27° to 28° C).

Age of shelters in weeks	Untreated carton (Repellency %)	Treated carton with 200mg/900cm² of MGK R-11	Roaming in test cage
0	—	—	100.0
0.5	100.0	0.0	0.0
1.0	97.5	2.5	0.0
2.0	93.8	5.0	1.2
3.0	70.0	27.5	2.5
4.0	67.5	32.5	0.0
0	—	—	100.0
0.5	100.0	0.0	0.0
1.0	93.8	3.7	2.5
1.5	92.5	7.5	0.0
2.0	85.0	15.0	0.0

Table 2. Percentage of roaches inhabiting shelters. Average of two replicates (at 27° to 28°C).

Age of shelters in days	Untreated carton		Treated carton with 200mg/900cm² of MGK R-11	Free roaming in test cage
	old	new		
0	0.0	—	0.0	100.0
2	100.0	0.0*	0.0	0.0
3	95.0	5.0	0.0	0.0
4	83.8	16.2	0.0	0.0
5	75.0	25.0	0.0	0.0
6	76.3	23.7	0.0	0.0
7	81.3	18.7	0.0	0.0
9	76.3	22.5	1.2	0.0
11	73.8	20.0	6.2	0.0
17	68.8	22.5	8.7	0.0
21	45.0	45.0	10.0	0.0
23	42.5	42.5	15.0	0.0
28	27.5	50.0	22.5	0.0

* Placed here.

the roaches settled down in either. The results indicate that where the roaches had a free choice of the two, they definitely preferred the untreated shelter, and once settled in a shelter, they did not remove the other at all.

Since the roaches have such a habit, the testing method by using shelters might be inadequate to determine the effectiveness of repellent.

c) A Method of Appraisal of Repellent Efficiency by Providing with Poisoned Bait

In this method, the criterion of repellency is based on the number of roaches killed by taking poisoned bait. The poisoned bait is placed in the test pen treated with repellent on its entire outer walls. During the repellent is effective, the roaches are not able to approach the test pen even if they are hungry, consequently, no or lower mortality is expected.

The test cage consisted of a wooden box, 60 cm long and 30 cm broad, and 15 cm in height, with a netted trap-door in the ceiling. On either inside wall of the cage was fitted with a board of 18×10 cm, at a space of 2 cm, and 3 cm from the bottom, so that the roaches could hide in the crevice. Test pen consisted

of cardboard screen. The size of the pen was 10×10×8 cm, and height of 8 cm was enough to allow roaches to climb up a wall and to enter into the pen.

In the tests, the entire outer wall of the pen was treated with acetone solution of a given amount of the test repellent, and, after the main part of the solvent had evaporated off, the treated pen was placed in the center of the test cage containing 40 adult roaches. Poisoned bait was provided in the treated pen, while only water was provided in the outside of the test pen. Poisoned bait used was a mixture of sugar and starch containing 2% of lindane because the roaches had preferred this mixture. The tests were made in a room lighted with fluorescent lamps which were on 10 hours and off 14 hours. Mortality counts were made once each day during the test periods. The results are given in Table 3.

Table 3. Percent repellency of MGK repellent 11 against the adult American cockroaches by the poisoned bait method. Test pen was treated with 200 mg/900 cm² of MGK repellent 11. Poisoned bait was provided in the treated pen. Average of two replicates (at 27° to 28° C).

Age of treated pen in weeks	Survival % (Repellency %)	Mortality %	Cannibalism %
0	100.0	0.0	—
0.5	100.0	0.0	2.5
1.0	100.0	0.0	2.5
1.5	98.8	1.2	—
2.0	90.0	10.0	—
2.5	56.7	43.3	—
3.0	15.0	85.0	—
3.5	10.0	90.0	—
4.0	2.5	97.5	—

d) Determination of Repellent Activity by Compulsory Feeding

In this method, the criterion of repellency is based on the amount of feeding on a fresh bait. Since a bait, starch without poison, is placed in test pen which has been treated on the outer wall with repellent, the hungry roaches are not able to eat the bait throughout the repellent is effective.

The methods and test conditions were nearly the same to those of last mentioned. In the test, however, applied bait was a fresh starch without poison, and it was renewed in each day. After the exposure of 24 hours the bait was removed and weighed. In the course of test, it was checked that an adult fed on starch of average 19.3 mg per day. The results are given in Table 4.

When the hygroscopic materials such as sugar and other ground cereal were used for test diets, they became often damp. In such a case, weight of moistened baits were corrected by the following formula :

$$tm = (R - R_0)/R_0 ,$$

where R_0 is weight of the bait before testing, R is weight of the same at the end of the test,

Table 4. Percent repellency of MGK repellent 11 against the adult American cockroaches by a compulsory feeding method. Test pen was treated with 200 mg/900 cm² of MGK R-11. Fresh bait, starch was provided in the treated pen. Average of two replicates (at 27° to 28° C).

Age of treated pen in weeks	Amount of feeding on starch in mg	Expected no. of roaches fed on bait	Repellency %
0	0.0	0/40	100.0
0.5	0.0	0/40	100.0
1.0	traces	0/40	100.0
2.0	99.0	5.1/40	87.3
3.0	635.0	32.9/40	17.8
4.0	750.0	38.9/40	2.8

Table 5. Comparison of repellent efficiency of MGK repellent 11 to the adult American cockroaches resulted from different testing methods. Dosage applied was 200 mg/900 cm² each.

Methods adopted	Repellency %				
	Elapsed time in weeks				
	0.5	1.0	2.0	3.0	4.0
Shelters	100.0	97.5	93.8	70.0	67.5
Poisoned bait	100.0	100.0	90.0	15.0	2.5
Compulsory feeding	100.0	100.0	87.3	17.8	2.8

Significance among the methods:
$\chi^2 = 115.113 > \chi^2_{0.05}$ (d. f. 8) = 15.507

and tm is an index of increased weight in blank test which keeping pace with the repellent tests. Actual amount of the bait fed by roaches is computed by the following formula :

$$\text{Actual bait eaten} = R_0 - \left\{ r/(1+tm) \right\} .$$

R_0 is weight of the bait given, r is remnants of the same, and tm is the index which is obtained from the blank test.

e) Comparison of the Repellent Effects Resulted from Various Testing Methods

As shown in Table 5, it is obvious that the repellent effect varies with the testing method. In the shelter method, high repellent effect of MGK repellent 11 to roaches must be influenced by the roach's habit so that once the roaches have inhabited in a shelter of their choice, they did not hide in other sheltered places easily. Of course, in the method, the roaches could not enter into the treated carton while the concentration of repellent is maintained sufficiently, but, since the roaches have such a habit it may be easily imaginable that they still avoid the treated carton even if the repellent becomes ineffective on them.

The other two methods may not be complete methods, but these may be sufficient for evaluating the repellent effects. Let us suppose that the treated pen as a kitchen which has been treated with repellent, and that the test cage with crevices which the roaches could hide as environment for their existence. Under these conditions, the repellent tests will proceed without intervention of the roach's habit.

Résumé

In the present paper, the author dealt with some methods to evaluate the effectiveness of a certain cockroach repellent in laboratory, and had compared the efficiencies with various testing methods. From the results so far obtained, poisoned bait or compulsory feeding method was adequate to measure the repellent effects in practice, whereas the shelter method was found to be inadequate to this purpose.

Although higher appraisal of repellent was obtained from the shelter method, these good results must be influenced by the reorientation of the roaches.

References

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Feeding Preferences in Certain Species of Adult Cockroaches. Insect Repellents and Attractants. IX. Yasunosuke IKEDA (Takamine Laboratory, Sankyo Co., Ltd. Yasu-cho, Shiga Pref.). Received Apr. 30, 1959. *Botyu-Kagaku*, **24**, 86, 1959.

18. ワモンゴキブリおよびクロゴキブリの嗜好性　忌避剤・誘引剤について　第9報

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ゴキブリの嗜好性を知るため，ワモンゴキブリおよびクロゴキブリの数種食料品に対する摂食試験をおこなった．この実験から，2，3の材料がゴキブリ駆除用の毒餌調整に効果的に使用できることを見出した．

In order to ascertain the food preferences of adult cockroaches, the feeding tests of a number of vegetable and dairy products to *Periplaneta americana* L. and *P. picea* Shiraki were carried out in laboratory. Some foodstuffs were found to be useful in the preparation of poison baits for the control of cockroaches.

The appearance of insecticide resistant roaches is becoming an increasingly important problem in various countries[1,4]. Nowadays, it has been well known that among several methods of applying insecticides for the control of certain insecticide resistant insects, the most